SECCHI
Sun Earth Connection Coronal and Heliospheric Investigation

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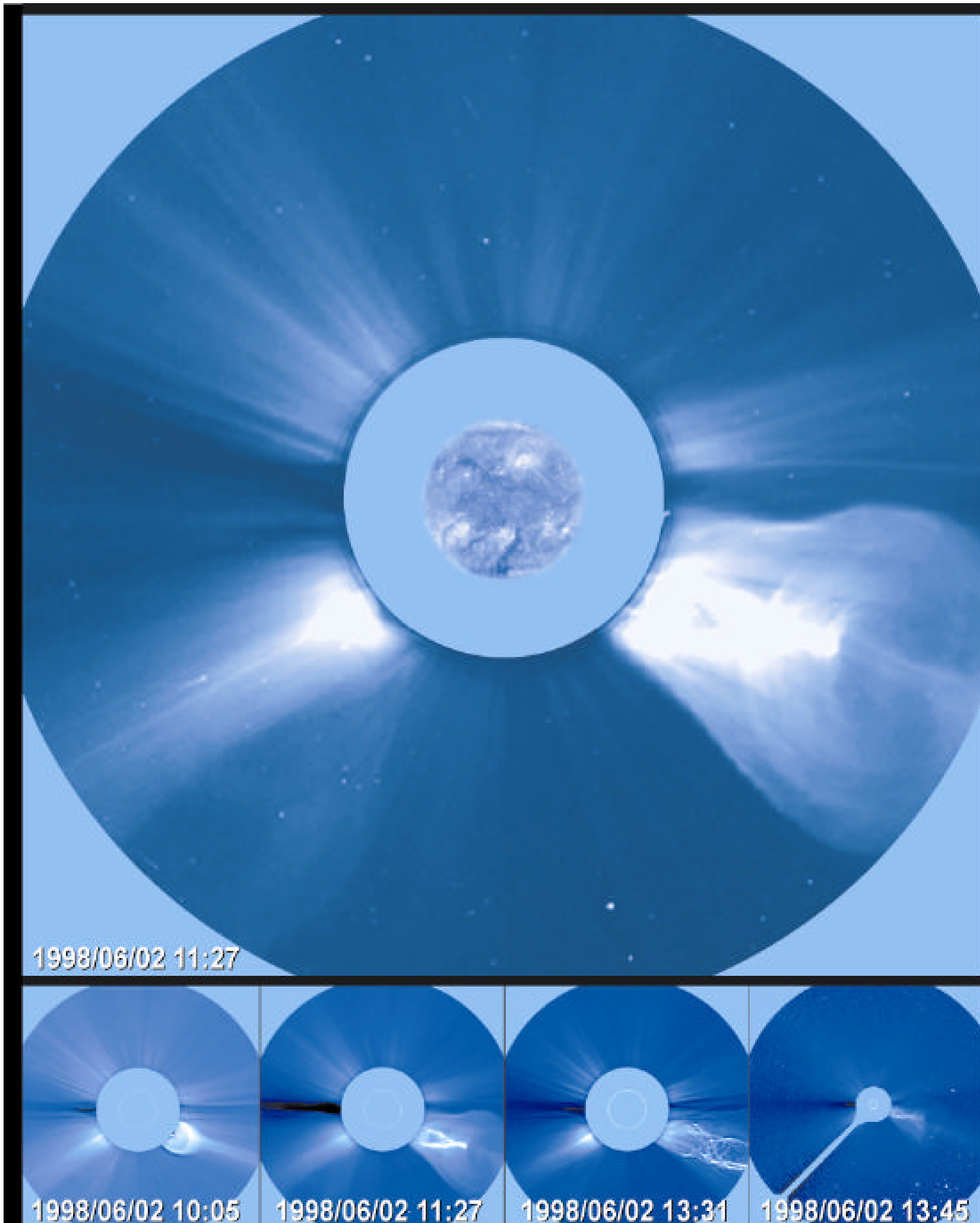
Presentation to Stereo SWG#1

27,28 January 2000

Web Site: http://secchi.pxi.com

Outline

- Science Description
- Modeling
- E/PO
- Instrument Description
- Accommodation
- Concerns



Sun Earth Connection Coronal and Heliospheric Investigation

SECCHI

NASA Goddard Space Flight Center

IAS orsay

Institut d'Optique

CSL

THE UNIVERSITY OF BIRMINGHAM

UCL

University College London

LOCKHEED MARTIN

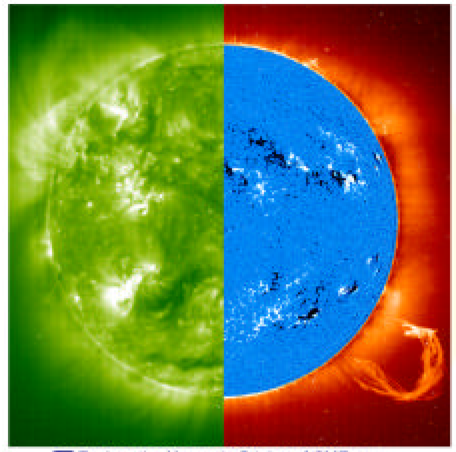
SOLAR AND ASTROPHYSICS LAB

NASA AO 99-OSS-01
Solar Terrestrial Relations Observatory (STEREO)

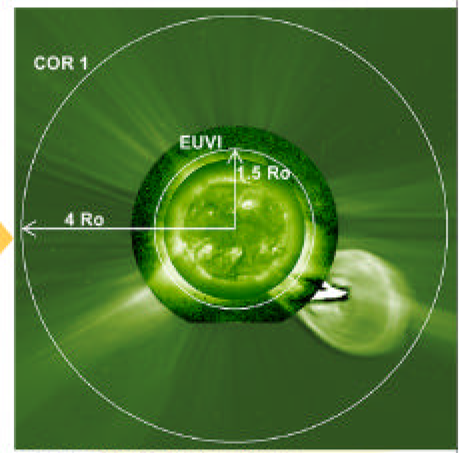
NASA

SECCHI Exploration of CMEs and the Heliosphere on STEREO

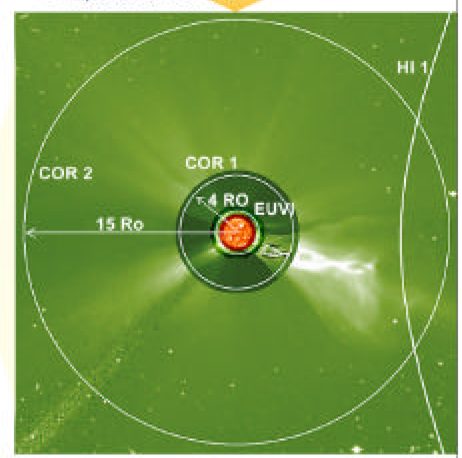
- *What Configurations of the Corona Lead to a CME?*
- *What Initiates a CME?*
- *What Accelerates CMEs?*
- *How Does a CME Interact With the Heliosphere?*
- *How do CMEs Cause Space Weather Disturbances?*



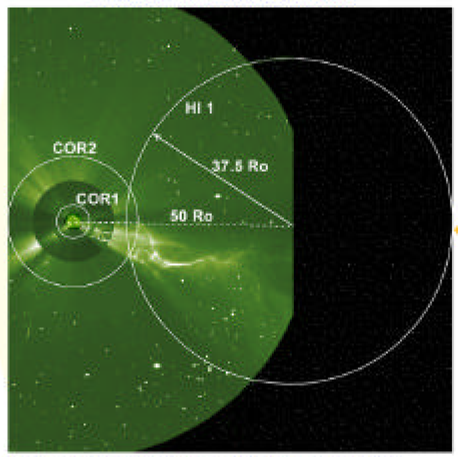
Explore the Magnetic Origins of CMEs
- Photospheric Shearing Motions
- Magnetic Flux Emergence
- Magnetic Flux Evolution and Decay



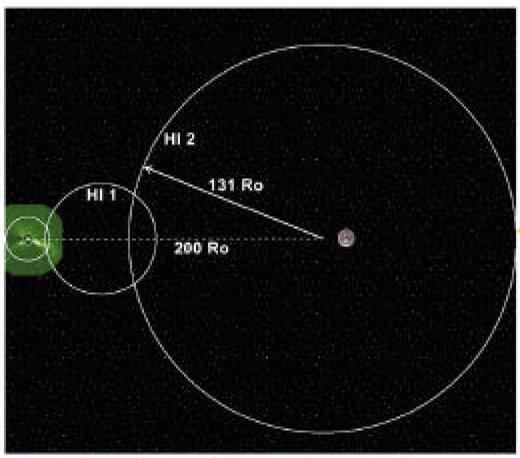
Understand the Initiation of CMEs
- Reconnection
- The Role of Plasma vs. Magnetic Field Effects
- Rapid vs. Slow Drivers



Study the Physical Evolution of CMEs
- Reconnection
- Continued Energy Input and Mass Ejection
- Effect on Helmet Streamers

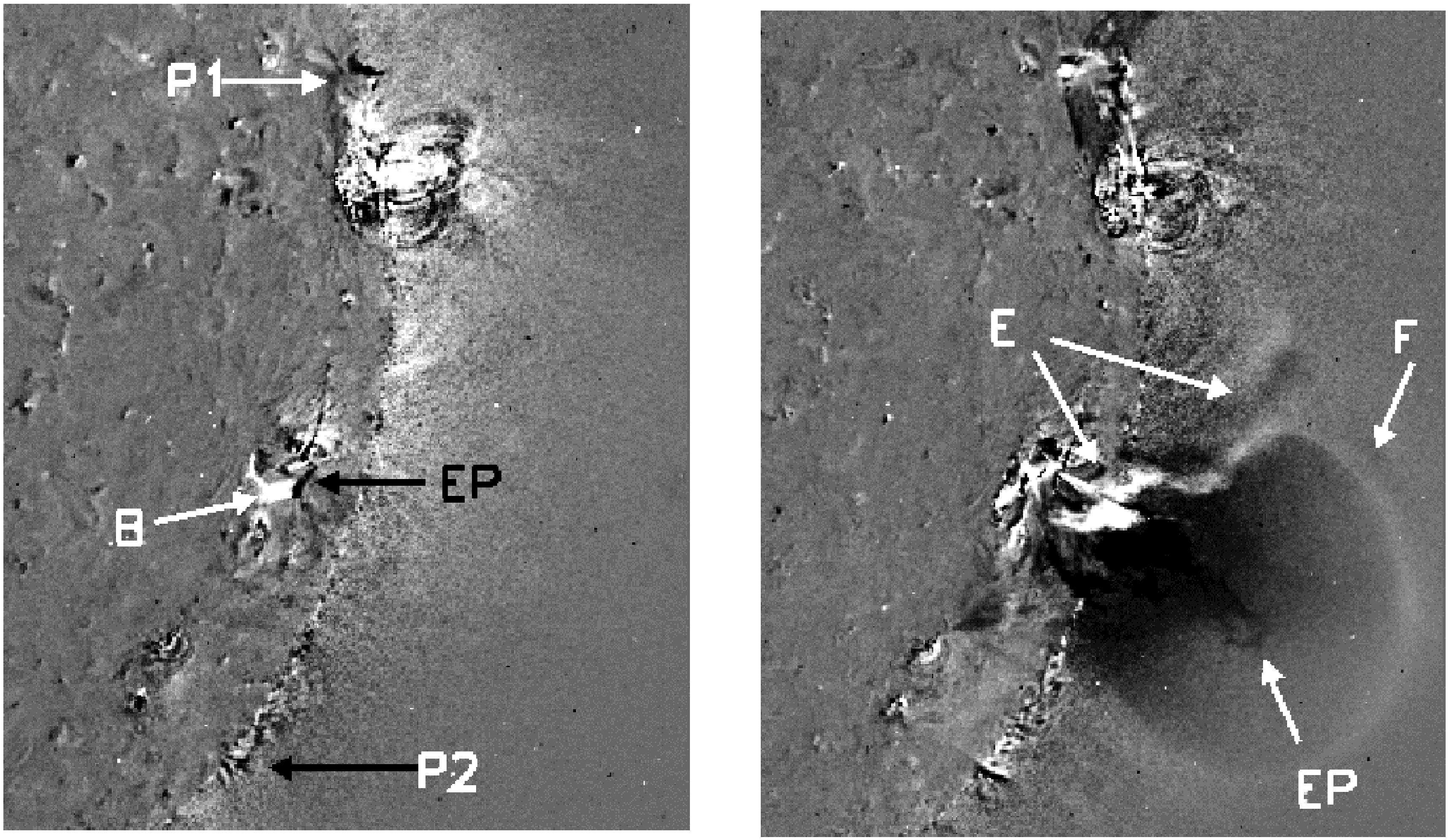


Investigate the Interaction of CMEs With the Heliosphere
- CME Physical Signatures at 1 AU
- Generation of Shocks
- Acceleration of Charged Particles
- Interaction With Heliospheric Plasma Sheet & Co-Rotating Interaction Regions
- Interaction With Other CMEs

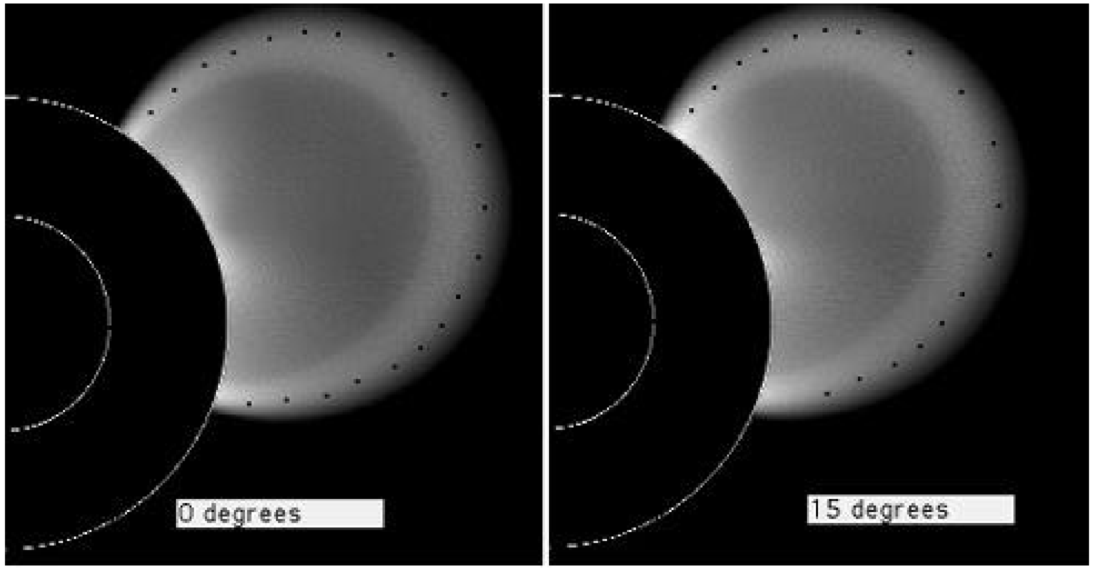


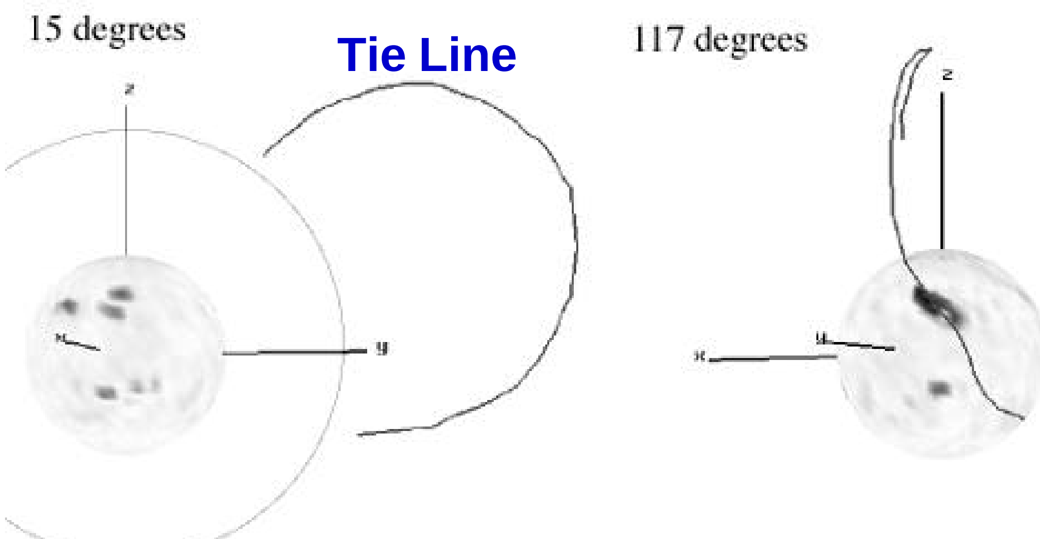
The Sun-Earth Connection: Understand the Role of CMEs in Space Weather
- Observe Trajectory of Earth-Directed CMEs
- Predict Arrival Time and Geo-Effectiveness of CMEs

CME INITIATION



EXAMPLE OF STEREO CME ANALYSIS





SECCHI Observables

Inst.	Observable	Wavelength	Pixel Resolution	Field of View	Nominal Cadence
VMAG*	Photospheric Magnetic Field	6302 A	2 arc sec	Disk	30 min
EUVI	He II Intensities	304 A	1.4 arc sec	<1.5 R	2.5 min
	Fe X, Fe XII, Fe XIV Intensities	171, 195, 211 A			
COR1	Intensity - B, pB, p	6500 to 7500 A	7.6 arc sec	1.1 - 4 R	8 min
COR2	Intensity - B, pB, p	4500 to 7500 A	14 arc sec	2 - 15 R	30 min
HI	Intensity - B	4500 to 7500 A	40 arc sec	12 - 84 R	60 min
			120 arc sec	66 - 318 R	60 min

*Descoped

SECCHI MHD Modelling

- Necessary to help interpret SECCHI observations and to connect them to the in-situ and radio observations
- 3 broad MHD objectives
  - Model the quasi-static plasma parameters
  - Investigate the physics of the initiation of CMEs
  - Propagate a transient structure into the heliosphere
- Other groups can use these model outputs as boundary values to modules to predict solar wind properties, energetic particles and radio emission.
- Must be ready at the time of launch!

SECCHI Data and Analysis Tools

- Available to the community at launch
- Calibration tracking tool
- Removal of energetic particle tracks
- Structure measurements
- Movie tool
- Potential B field tool
- Emission measure map tool
- Image visualization tools (single/multiple instrument)
- Three-dimensional image reconstruction
- CME propagation modeling tool

SECCHI Data Archive

- DVD Disks
  - Double Sided Double Density => 17 Gbytes capacity
  - Containing data from both S/C for 2 days
- Will include
  - SECCHI Data
  - Steady State Model
  - Propose to include other Stereo instruments
- Distribution
  - To all Co-I institutions
  - NASA SDAC

Guest Investigator Program

- SECCHI has included funding (~$2M) in its budget for a GI program
- Administered by NASA
- Supplement to the normal NASA GI program
- Would start 1 year before launch

SECCHI Education & Public Outreach

- Develop web pages
- Develop Master teacher workshops and self-contained educational toolkits, educational CD-ROM
- Develop Stereo component of SUNBEAMS
- Support 1 teacher/year to work with SECCHI scientist
- Develop “low-tech” planetarium show on Sun and space weather
- Produce SECCHI images and animations for E/PO
- Maintain interactive programs with K-12 schools

SECCHI Mass, Size, Power

	Mass (kg)	Size (cm) (l x w x h)	Power (W)
Electronics Box	11.6	24.1x17.8x20.3	23.2
Sun Centered Imaging Package	20.8	131 x 24.6 x 28	10.2
Heliospheric Imager	4.3	68.6 x 32.4 x 18	6.5
Totals	36.7		39.9

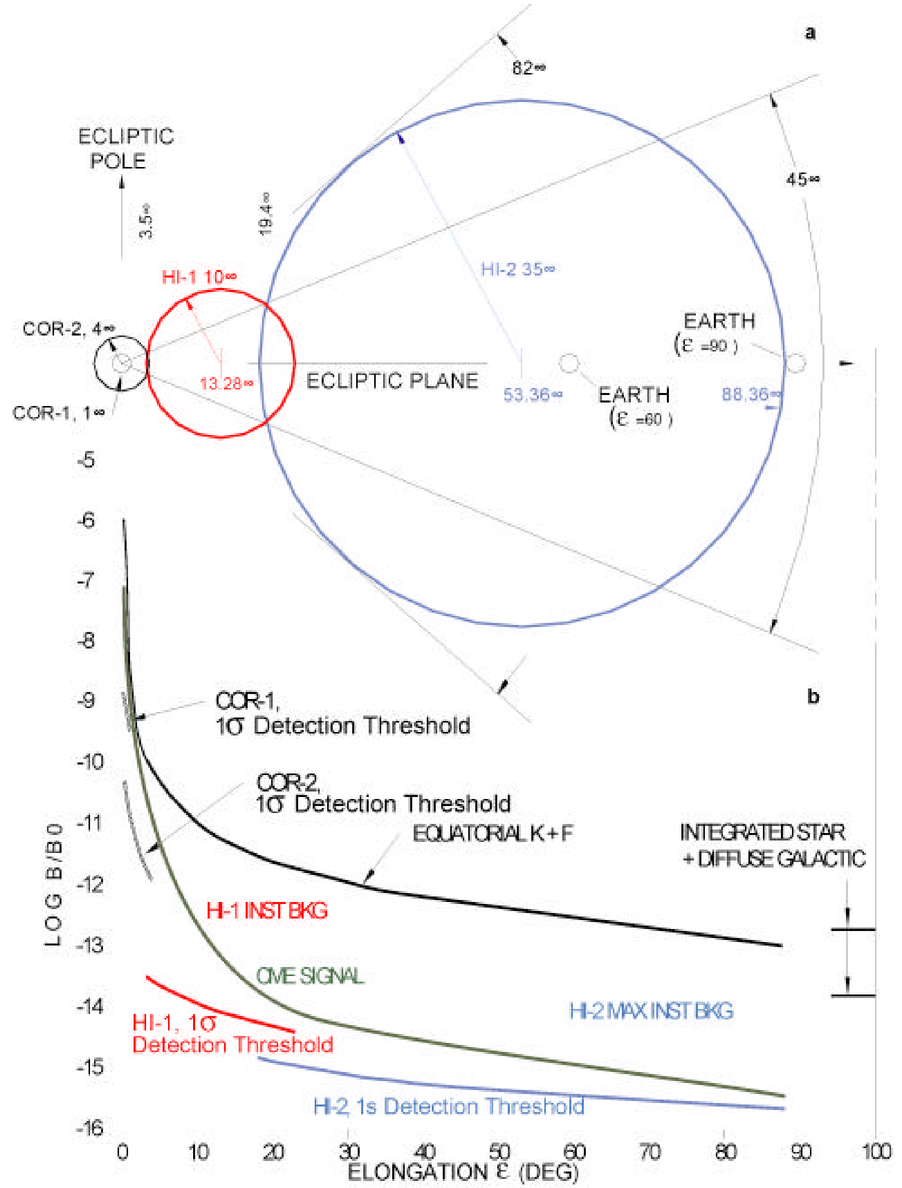
SECCHI Instrument Heritage

COMPONENT		Heritage
EUVI	Optics	Trace, EIT
	Coatings, Entrance and exit filters	NIXT, MSFC/LMSAL, EIT, Trace
	Active Mirror Assembly	MDI, Trace
	Quadrant Mask	MDI, SXT, Trace
	Filter Wheel	MDI, Trace
GuideScope	Optics	Trace
COR1	Optics	Mauna Loa MK3 Coronagraph
COR2	Optics	LASCO C3
HI	Optics	LASCO approach with traditional designs
Common electronics and mechanisms	1/2 wave plate mechanism (3), mechanism driver electronics, instrument analog monitor board, electronics enclosure	MDI, Trace
	Focal plane shutters (all)	MDI, Trace
	Power Distribution, Power converter for computer	Trace
	RAD6000 DPU	SXI, SMEX-Lite, Triana EPIC
Cameras	CCD Readout Electronics	SMEI
	CCDs	SXI, Solar-B, Rosetta Oasis
Doors	Door Assembly, PA, PA electronics, encoders	LASCO, EIT
Instrument Suite	SCIP Structure	FORTE
	HI Structure	Solar -B, SMEI
	Software	SMEX-Lite, SXI, LASCO
	Firmware	SMEX-Lite

SECCHI Mechanisms

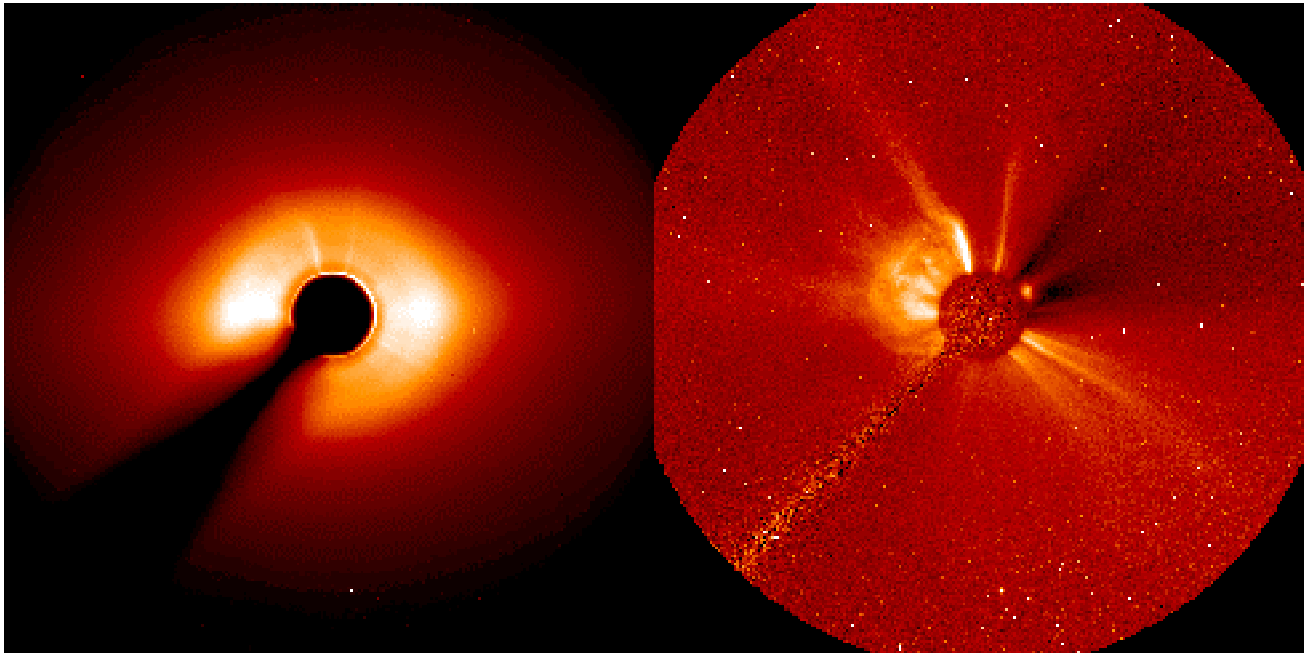
- EUVI
  - Bandpass Mask
  - Filter Wheel
  - Shutter
  - Door
- COR1
  - Rotating wave plate
  - Shutter
  - Door
- COR2
  - Rotating wave plate
  - Shutter
  - Door
- HI
  - Shutter
  - Door

HI-1 (Red) and HI-2 (Blue) Fields of View

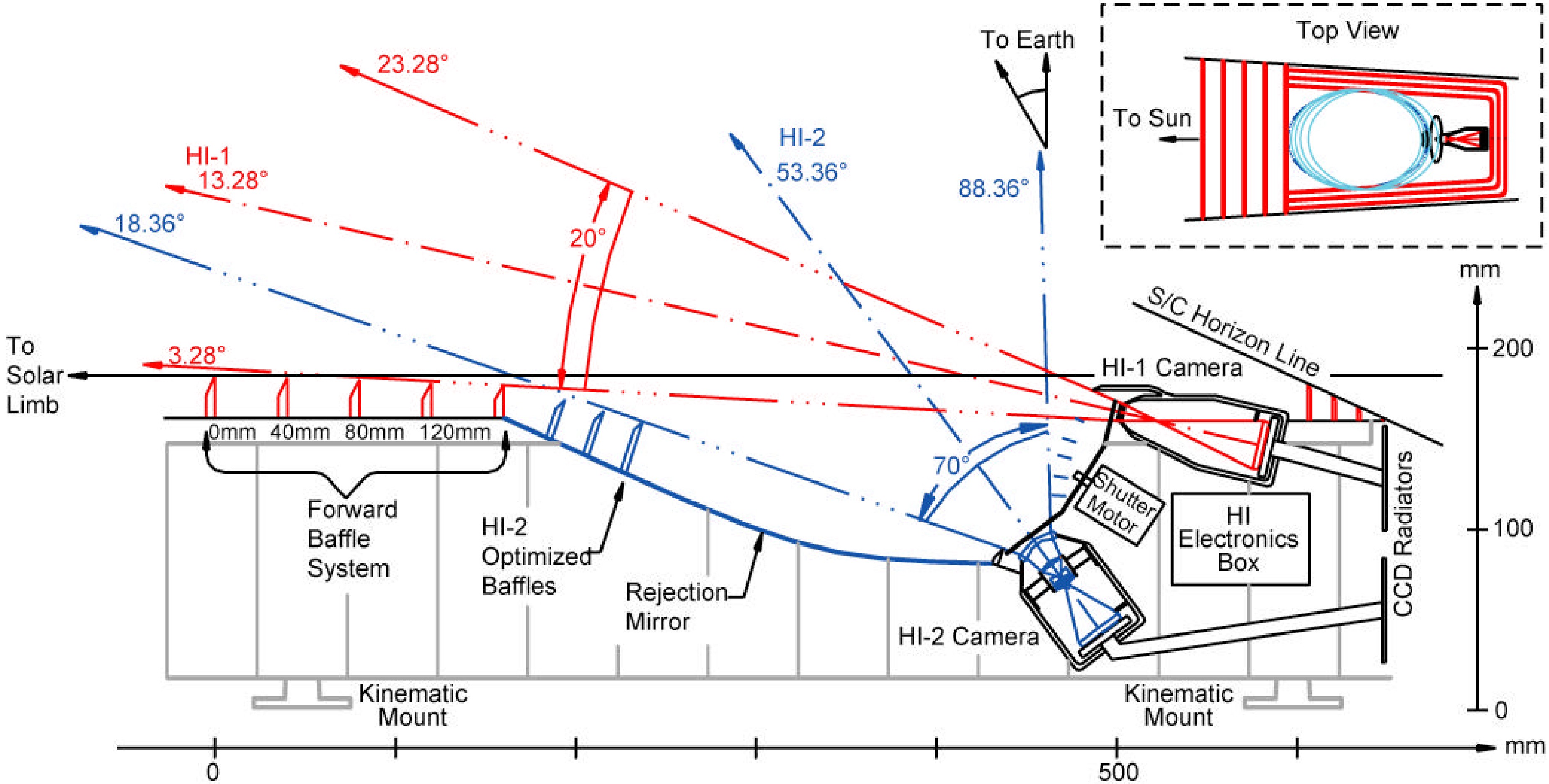


Stray/Zodiacal Light Model Subtraction

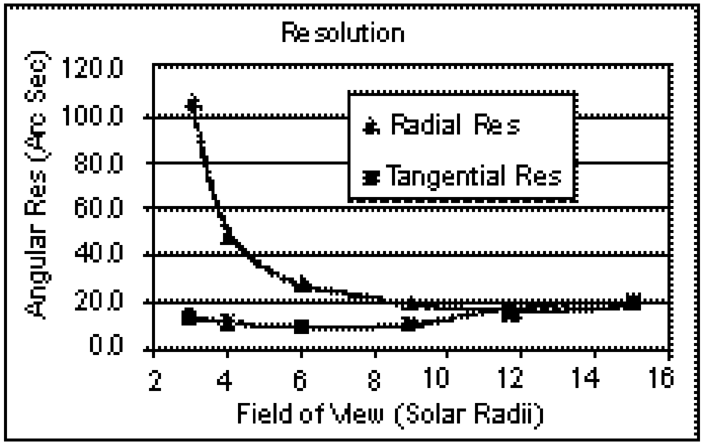
LASCO/C3 Coronal Image Taken on 20 June 1999: The Left Panel Shows the Typical Football Shaped Distribution of the Zodiacal Light (F-corona) That Overlies the Dimmer K-corona at Moderate and Long Elongations From the Sun. In the Right Panel, the Zodiacal Light and the Stray Light Have Been Removed to Show Clearly the Background Stars, Coronal Streamers and a CME in Progress in the North East.



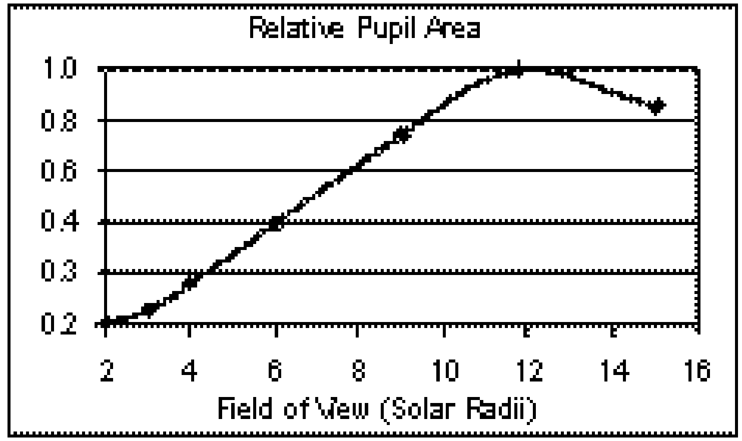
Heliospheric Imager (HI) Instrument Parameters
Concept Diagram HI-1 (Red), HI-2 (Blue)



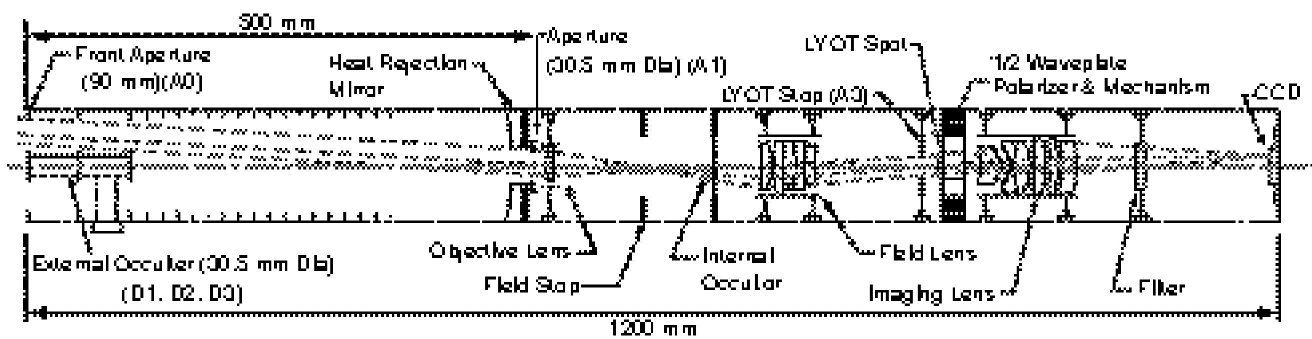
Coronagraph 2 (COR2) Instrument Parameters



Resolution

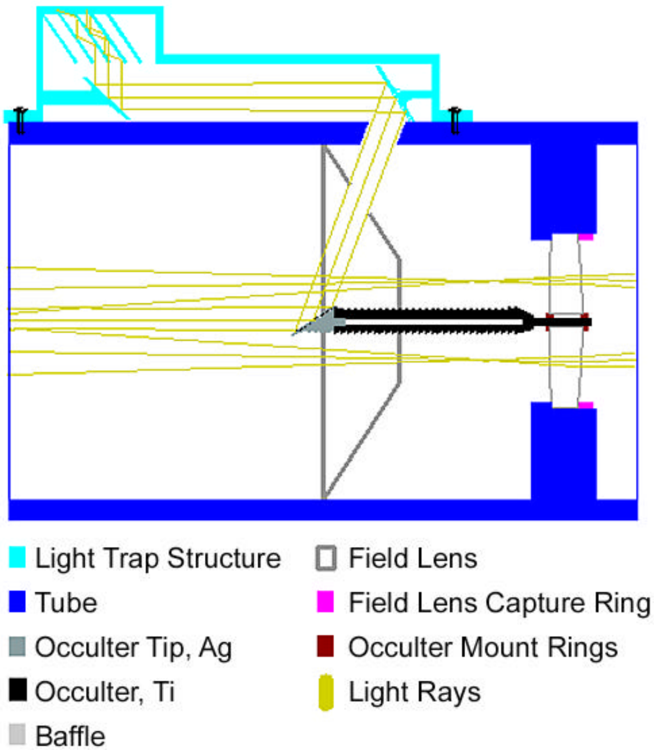


Vignetting

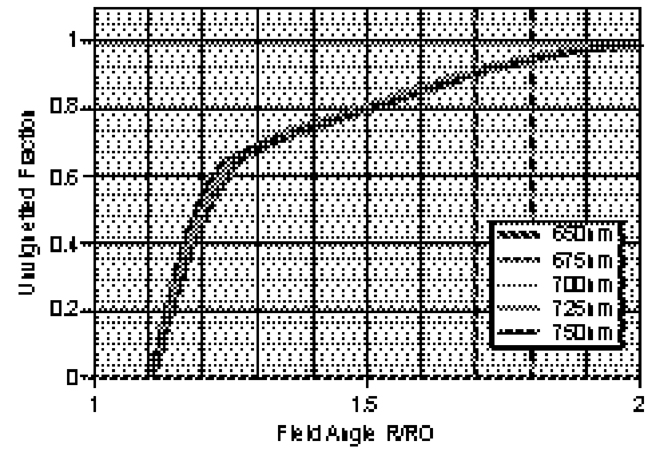


COR2 Optical Layout

Coronagraph 1 (COR1) Instrument Parameters

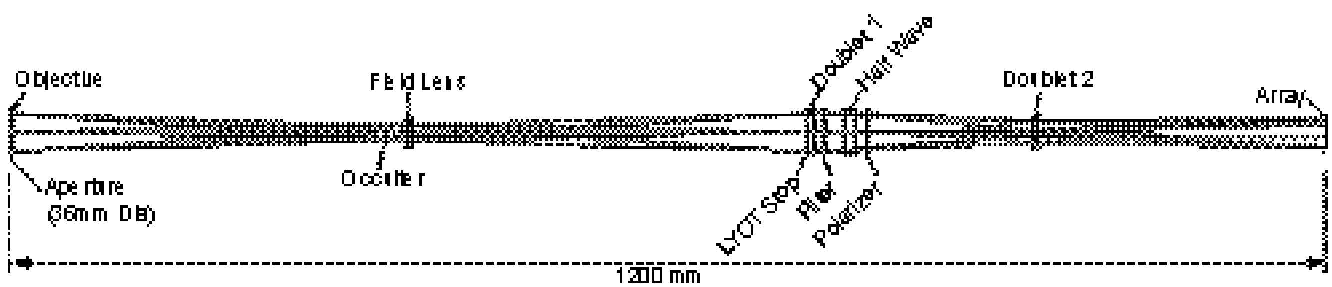


COR1 Field Lens/Occulter Detail



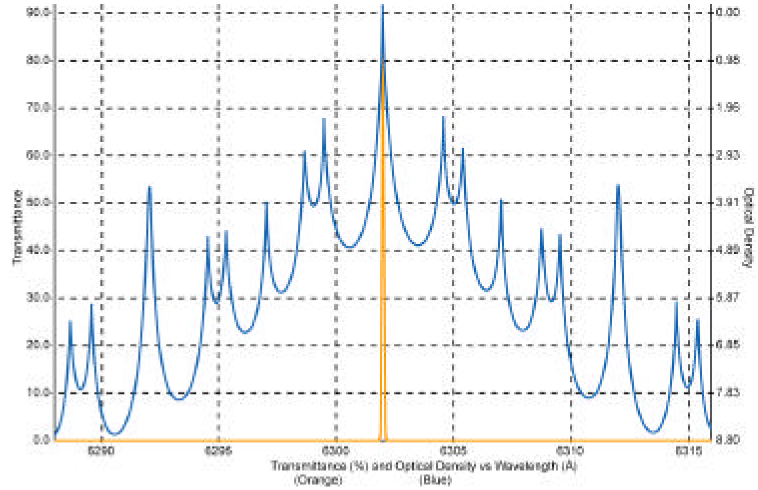
Vignetting

Axial Color From the Singlet Object Leads to Vignetting at the Occulter. The Vignetting Has a Chromatic Character Inside of 1.3 R0.

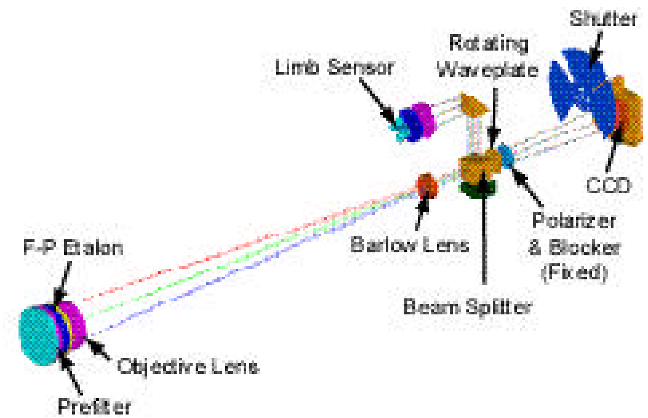


COR1 Optical Layout

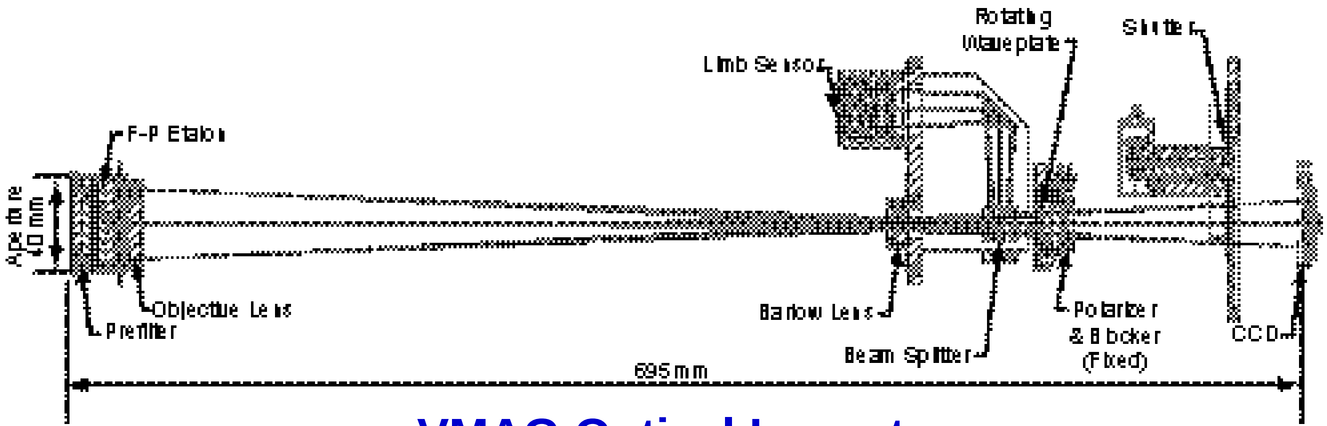
Vector Magnetograph and Guide (VMAG) Scope Instrument Parameters



Transmission Profile of Magnetograph Fabry-Perot

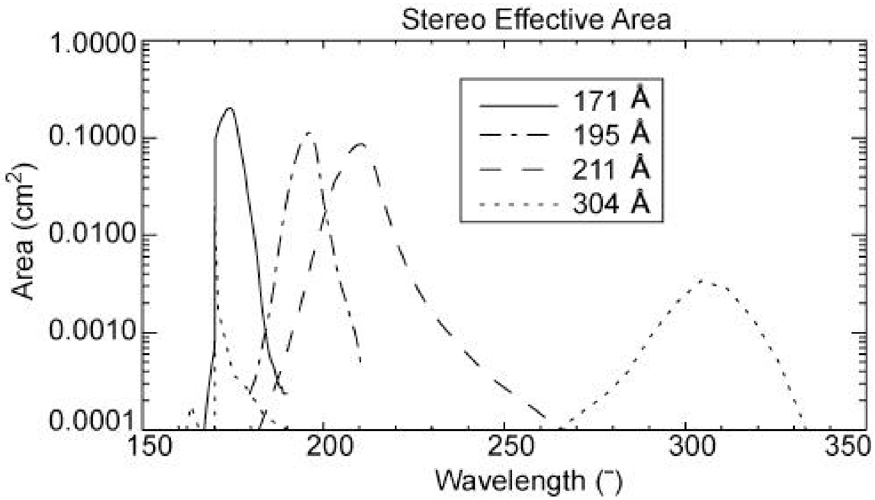


VMAG Optical Elements

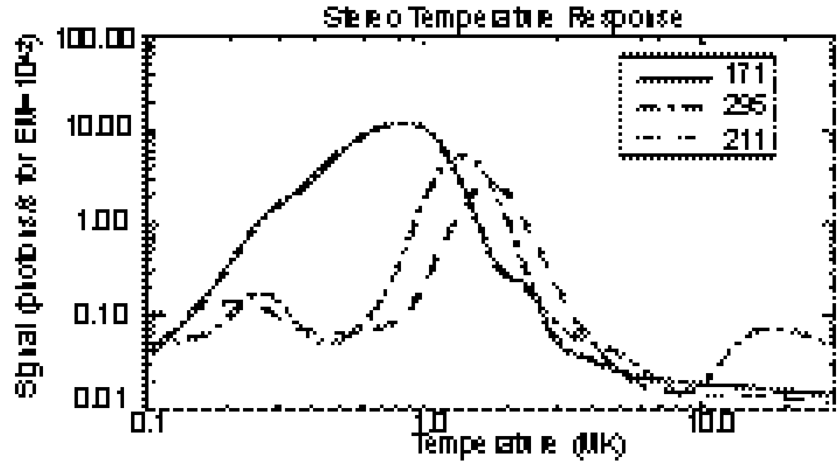


VMAG Optical Layout

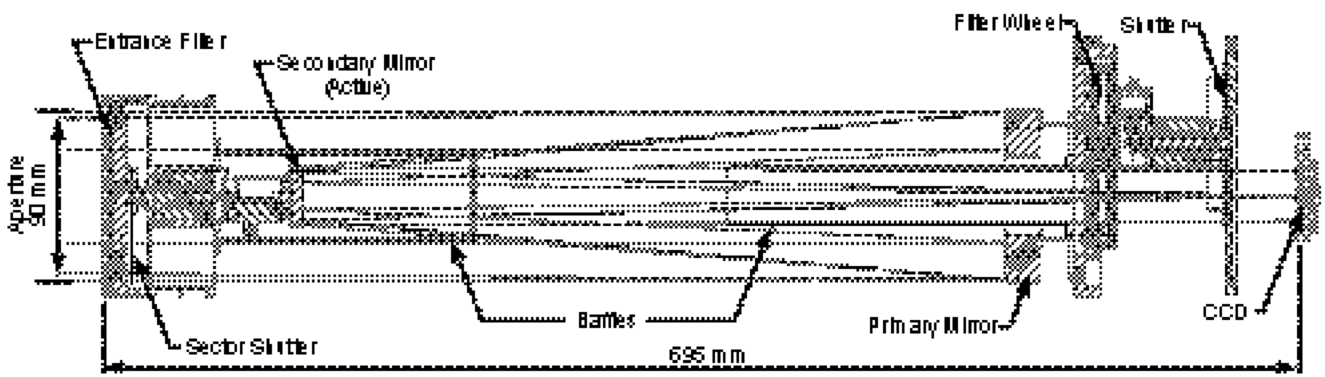
Extreme Ultraviolet Imager (EUVI) Instrument Parameters



EUVI Effective Layout



EUVI Temperature Response



EUVI Optical Layout

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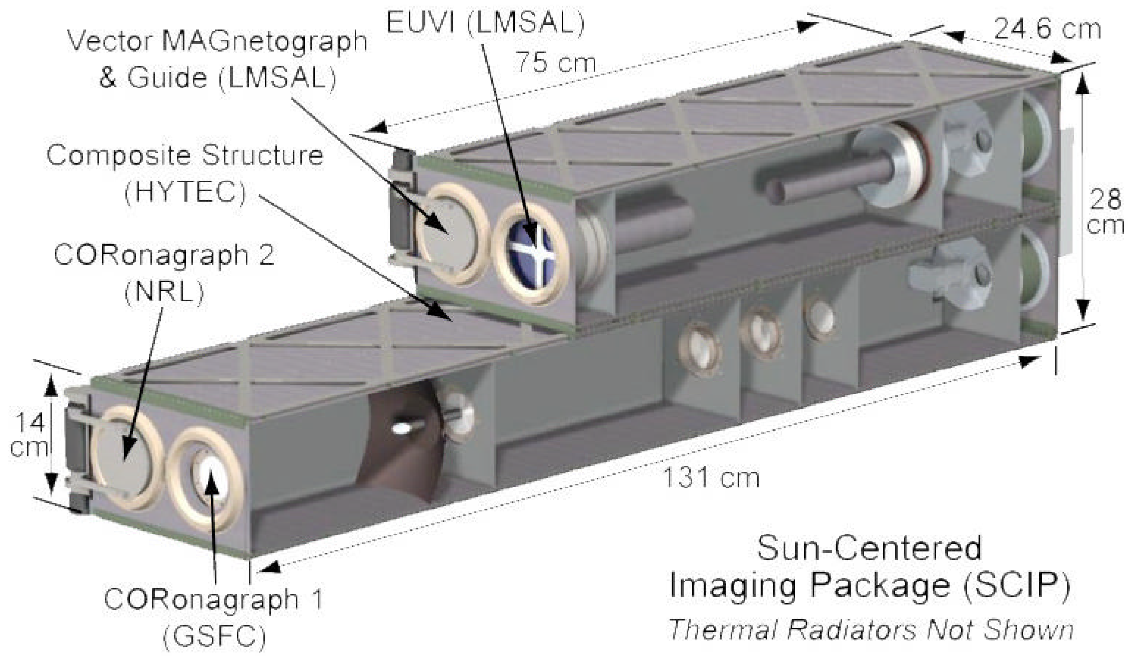
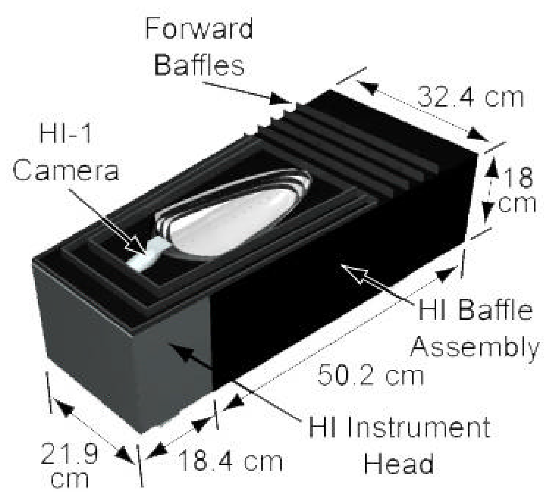
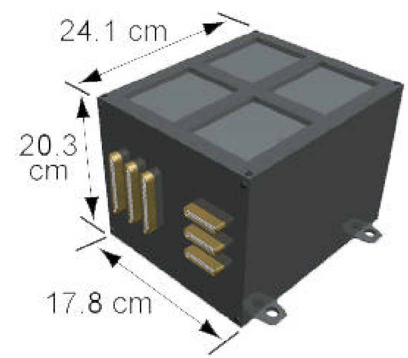


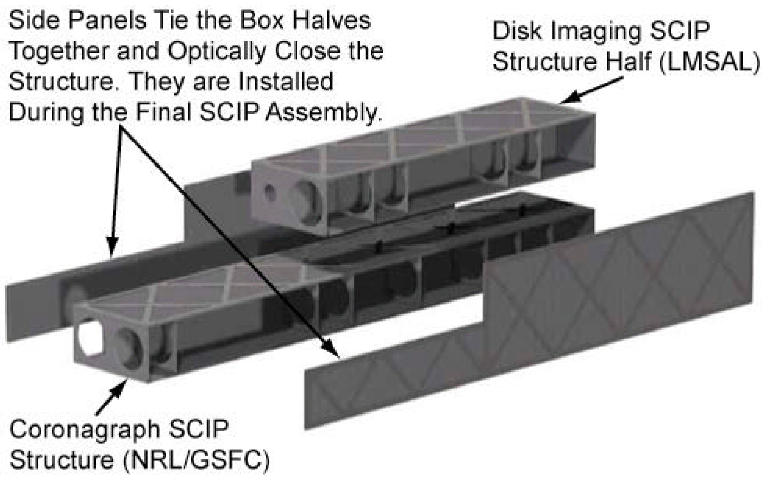


Heliospheric Imager (HI)
and Baffle
(University of Birmingham)

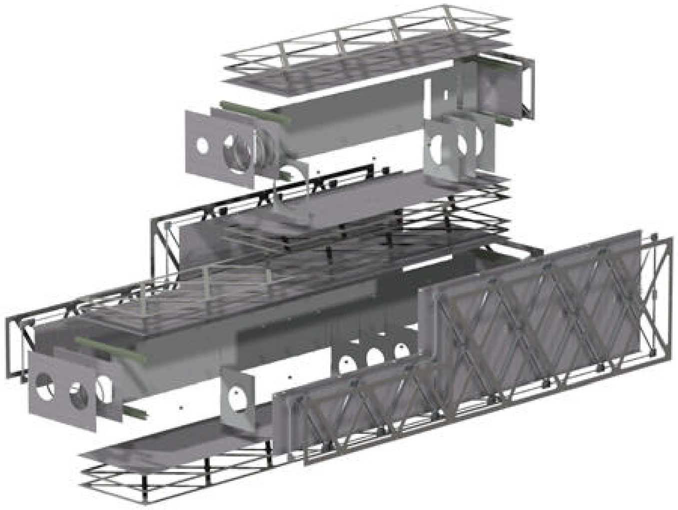


SECCHI Electronics Box (SEB)
(LMSAL)

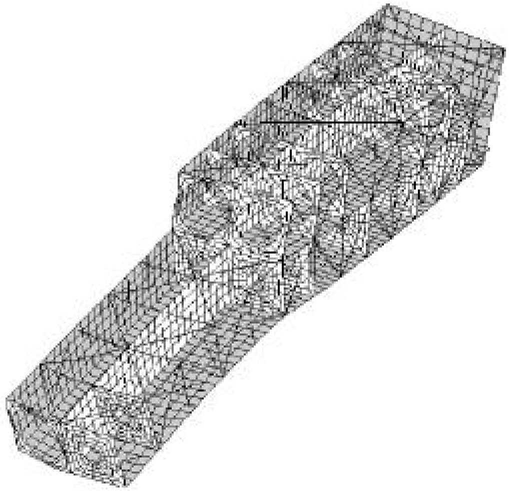
SCIP Composite Optical Box



Low-Outgassing GrCE Composite Material

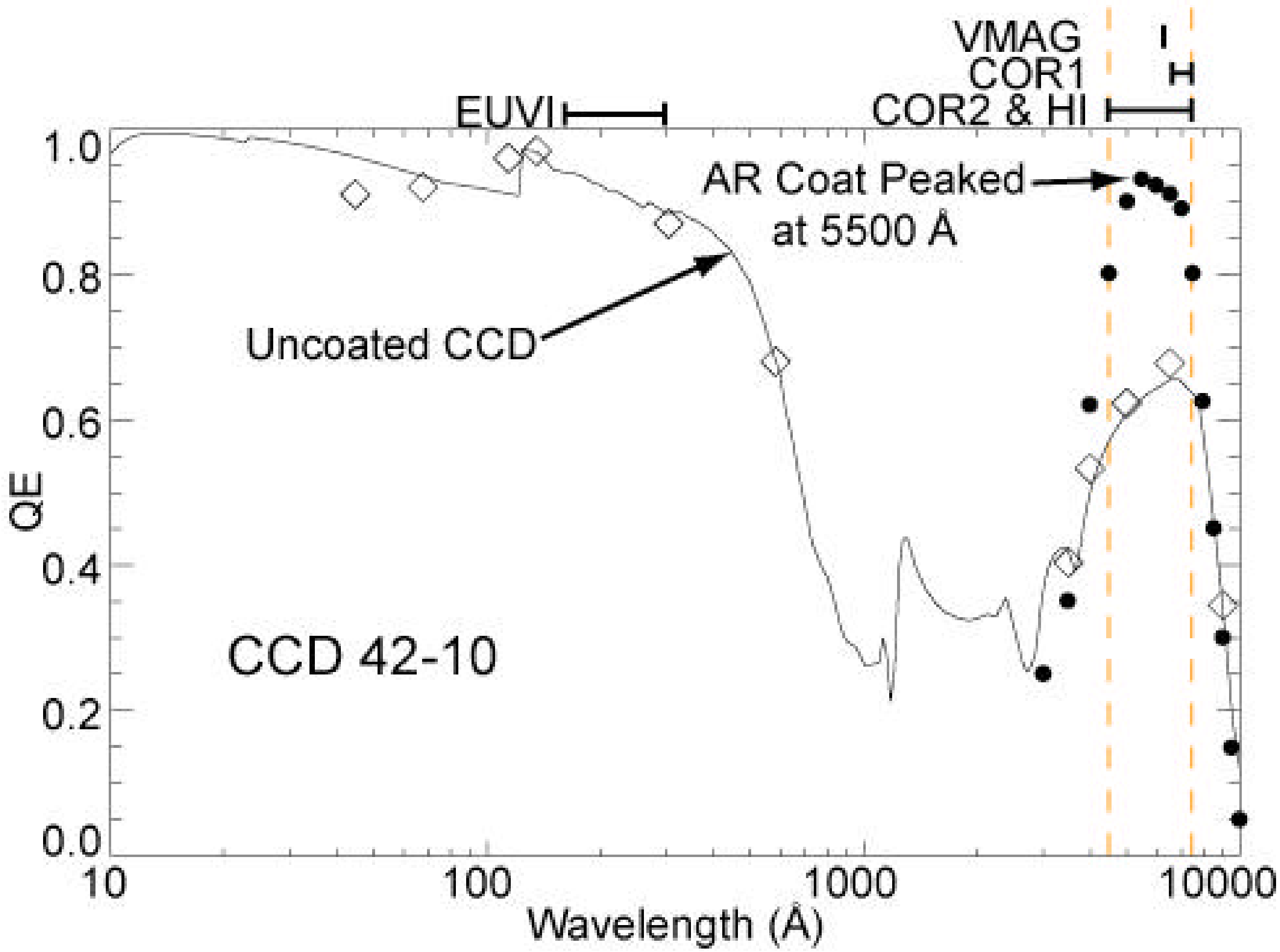


Detailed Optical Box Design Reduces Development Risk



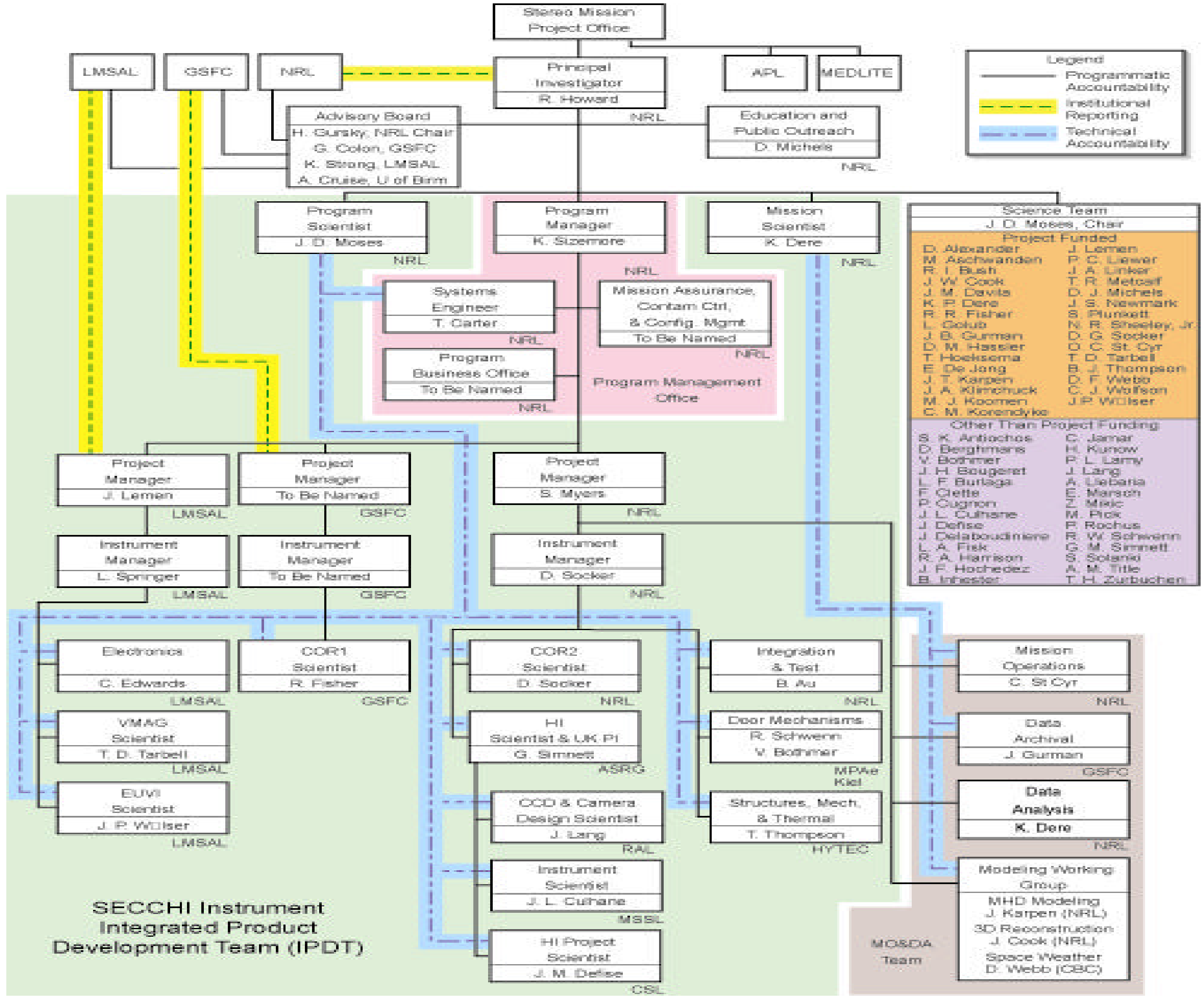
High Fidelity FEM Model Shows Primary Mode (149 Hz)

Measurements of the Quantum Efficiency of a UV Enhanced CCD

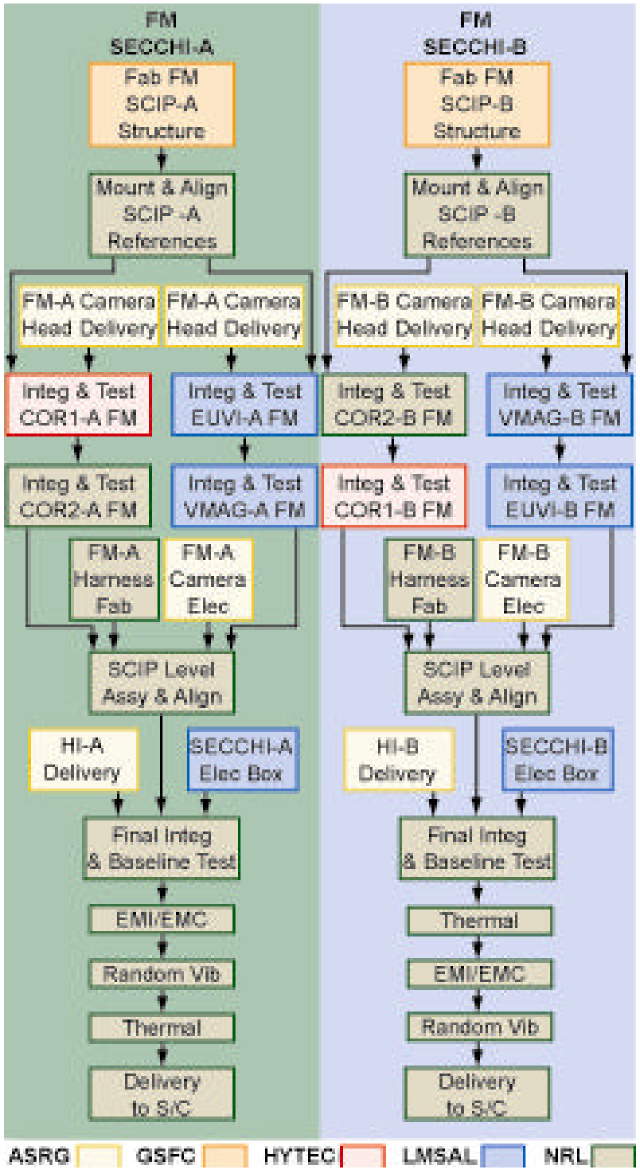


No Anti-Reflection Coating is Used on the EUVI Detector

SECCHI ORGANIZATION



SECCHI INTEGRATION FLOW



SECCHI Concerns/Uncertainties

- Pointing
  - Stability
  - Clear field of view
- Alignment
  - Co-alignment to be checked before/after vibration
  - Coronagraph internal alignment to be checked before/after vibration
- Mass, size
  - Proposal was constrained to meet the perceived Pre-phase A S/C
  - There are trade-offs we can make if there is some flexibility here, eg. Square off the SCIP box, Composite to Aluminum
- Power
  - Power seems to be the major S/C constraint
  - Concern about the amount of heater power that might be necessary

SECCHI Pointing/Alignment Requirements

	Hi	COR2	COR1	EUVI
Alignment Tolerance	0.5 mm	1 arc min	125 micron	200 micron
Absolute Pointing	30 arc min	45 arc sec	10 arc sec	3 arc min
Pointing Stability	0.5 arc min over 1 hour	1.5 arc sec over 20 seconds	1.5 arc sec over 10 seconds	1.5 arc sec over 40 sec
Long Term Pointing	5 arc min over month	5 arc sec over month	5 arc sec over month	

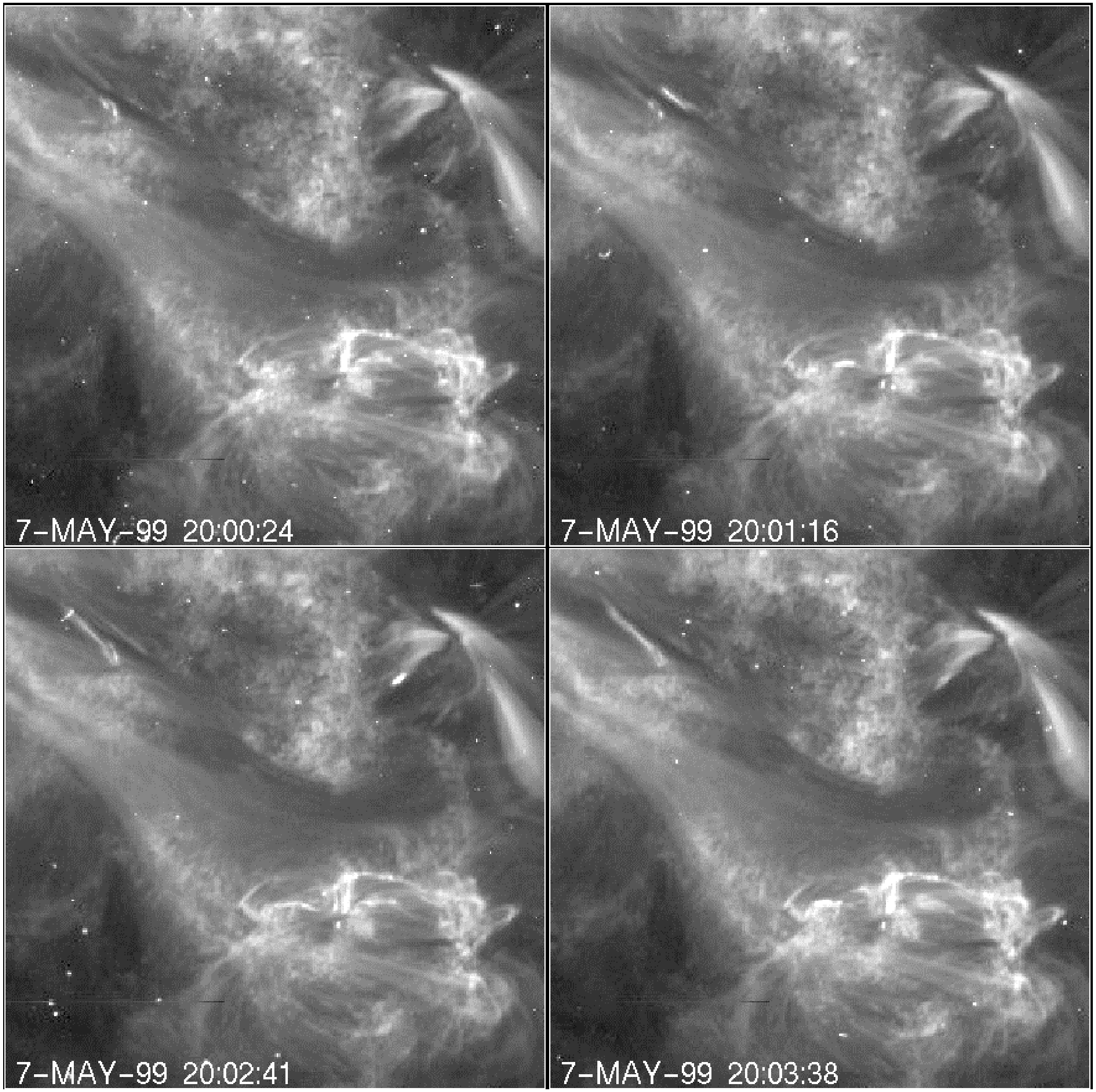
SECCHI Accommodation Concerns (Contd)

- **Telemetry**
  - In order to do a pB sequence before a CME has moved across a COR1 pixel, the SECCHI telescopes are capable of very fast operation, removing a major design limitation of the SOHO LASCO/EIT.
  - SECCHI is very flexible in its internal TM allocation among the various telescopes
  - There are times when an extremely high cadence is required
  - A variable daily data volume could be implemented as the S/C separate from Earth

Example of fast evolution from TRACE.

Significant changes even with a 1 minute cadence

Note jet in upper left and changes to active region



SECCHI Telemetry Options

Telemetry Considerations for STEREO Telescopes									
Telescope	Cadence (min)	# images	Image Size	Compress Factor	Factor Xmitted	MBytes per cadence	GBits/Day	Images/Day	Rate kbps
Option 1 (Proposal Table with descope of VMAG)									
EUVI	2.5	2	1024	10	0.785	0.33	1.52	1152	15.01
EUVI	30	2	2048	10	0.785	1.32	0.51	96	5.00
COR1	8	3	1024	10	0.75	0.47	0.68	540	6.72
COR2	30	3	2048	10	0.985	2.48	0.95	144	9.41
HI-1	60	1	1024	2	1	1.05	0.20	24	1.99
HI-2	120	1	1024	2	1	1.05	0.10	12	1.00
						Total	3.96	1968.00	39.13
Option 2 (Increased EUVI)									
EUVI	2.5	2	1024	10	0.785	0.33	1.52	1152	15.01
EUVI	10	2	2048	10	0.785	1.32	1.52	288	15.01
COR1	8	3	1024	10	0.75	0.47	0.68	540	6.72
COR2	30	3	2048	10	0.985	2.48	0.95	144	9.41
HI-1	60	1	1024	2	1	1.05	0.20	24	1.99
HI-2	90	1	1024	2	1	1.05	0.13	16	1.33
						Total	5.00	2164.00	49.46
Option 3 (Increased WLC)									
EUVI	2.5	2	1024	10	0.785	0.33	1.52	1152	15.01
EUVI	30	2	2048	10	0.785	1.32	0.51	96	5.00
COR1	5	3	1024	10	0.75	0.47	1.09	864	10.75
COR2	15	3	2048	10	0.985	2.48	1.90	288	18.83
HI-1	60	1	1024	2	1	1.05	0.20	24	1.99
HI-2	120	1	1024	2	1	1.05	0.10	12	1.00
						Total	5.32	2436.00	52.57
Option 2 (Highest Cadence EUVI and WLC)									
EUVI	0.33	1	2048	10	0.785	0.66	22.99	4364	266.06
COR1	0.67	3	1024	10	0.75	0.47	8.11	6448	93.90
COR2	10	3	2048	10	0.985	2.48	2.86	432	33.05
HI-1	30	1	1024	2	1	1.05	0.40	48	4.66
HI-2	60	1	1024	2	1	1.05	0.20	24	2.33
						Total	34.56	11315.40	400.01

SECCHI Accommodation Concerns (Contd)

- Contamination
  - Extremely sensitive to particulate and molecular contamination at apertures
  - Dry Nitrogen Purge for SCIP
  - Contamination needs to be addressed at the design phase
  - Witness plates to be examined after major system tests
  - Only open the coronagraph doors in Class 100
  - Cannot accept thruster gas over the apertures => may need to add doors that can be cycled => mass and power
    - GuideScope and EUVI don't need
    - HI, COR1, COR2 TBD

SECCHI Accommodation Concerns (Contd)

- **Thermal issues**
  - **Concept for thermal radiators for CCD cameras (-60 C)**
  - **Power for CCD heaters during initial operations and whenever instrument is off**
  - **Non-op heater power for HI, SCIP and SEB**
  - **Location of SEB => collective thermal control**
- **I&T**
  - **Stimuli get put in front of the apertures during some tests**
  - **Alignment/co-alignment activities**
  - **Witness plate replacement**
  - **Will utilize a test connector when on the S/C**
  - **Final “button-up” activity as late as possible**

SECCHI Concerns (Contd)

- Parts program
  - GSFC could be a big help
  - Availability of high reliability parts e.g. CPU, 14/16 bit ADC, etc
- Schedule, Funding
  - We want the mission to succeed (eg not to exceed cost cap), but ...
  - startup delayed 4 months from AO/Proposal dates => shrinkage in overall schedule from what we proposed
  - $$ not matching schedule => inefficiency in our program => delays